Appendix E

Rule 132 Declaration E - **Calculation of Component Values Needed To Produce Operation According To Inventive Principles**

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Rule 132 Declaration E - Calculation of Component Values Needed To Produce Operation According To Inventive Principles

James Arthur declares as follows:

1. I am the inventor in the above patent application.

2. On or about January 10, 2002, Applicant obtained and tested an example of the Wener device described in US Patent 6,366,028 B1. Power consumption and luminous output were tested and recorded over a range of operating voltages, and switching waveforms were viewed and recorded at several supply voltages.

3. The Wener device was found to contain the circuit represented in Applicant's drawing Fig. 1b, where
   a. Inductor L1B had a value of 220 microhenries
   b. Light emitting diode D1B had a forward voltage of 4.2 volts
   c. Resistor R3B had a value of 1,800 ohms
   d. other component values were as described in US 6,366,028 B1, Wener, et al., col. 5, Table 1.

4. At a supply voltage of 1.5 volts, the Wener device was found to operate at a frequency of 671 kilohertz, utilize an on-time tON of 1.03 microseconds, and draw 90 milliamperes from the power supply.

5. Referring to Fig. 1b. in Applicant's drawings, the following calculations reflect the component values required to create, from that diagram, an embodiment of Applicant's instant invention employing the inventive principles of operation of same, where:

   a. Inductor L1B has a value of 220 microhenries

   b. Power supply voltage Vcc supplies a voltage of 1.5 volts

   c. Light-emitting diode D1B has a forward voltage of 4.2 volts

   d. Resistor R3B has a value of 1,800 ohms

   e. The average current drawn from power supply Vcc is 90 milliamperes.

PEAK INDUCTOR CURRENT

6. The instant invention operates by charging an inductor--storing energy into same--for an 'on' time, then discharging said inductor into a load until the discharge voltage across said inductor reverses, signalling that the energy stored in said inductor has been fully depleted.

7. The current drawn by the instant invention from its power source Vcc is, to a first approximation, identical to that in the inductor L1B. Said current varies from 0 to some peak current i_{pk} as the inductor charges, and from i_{pk} to 0 as the inductor discharges.

8. The average current drawn is given by $i_{avg} = i_{pk} /2$ **(Eqn. E-1)**

9. From Eqn. E-1, to draw an average current of 90 milliamperes, i_{pk} =180 milliamperes.

ON-TIME CALCULATION

10. Solving Eqn. 1 from Applicant's specification, pg. 2 for tON yields:

$$tON = \frac{\Delta i \bullet L}{Vcc} \qquad \textbf{(Eqn. E-2)}$$

11. From eqn. E-2, the time needed for a 1.5volt supply to charge a 220 microhenry inductor from zero milliamperes to a peak current of 180 milliamperes is calculated to be:

$$tON = \frac{0.180 \text{ amperes} \times 220 \text{ microhenries}}{1.5 \text{ volts}} = 26.4 \text{ microseconds}$$

12. From equation 2a. of Applicant's specification, pg. 4, between paragraphs 4 and 5, where light-emitting diode D1B has a forward voltage Vf of 4.2 volts, the time needed to discharge this 0.18 ampere current from the inductor is given by:

$$tOFF = \frac{iL \bullet L}{Vf\text{-}Vcc}, \text{ or } \frac{0.18 \text{ amperes} \times 220 \text{ microhenries}}{4.2 \text{ volts} - 1.5 \text{ volts}} = 15.8 \text{ microseconds}$$

13. The proportion of the cycle devoted to charging inductor L1B (Eq. 4, pg. 8 of Applicant's specification) is given by:

$$\text{duty cycle} = \frac{tON}{tON + tOFF} = \frac{26.4 \text{ microseconds}}{26.4 \text{ microseconds} + 15.8 \text{ microseconds}} = 62.5\%$$

14. The frequency of operation of the resulting converter embodying the teachings of the instant invention and the assumptions of section 5. above is given by:

$$f = \frac{1}{tON + tOFF} = \frac{1}{26.4 \text{ microseconds} + 15.8 \text{ microseconds}} = 23.7 \text{ kilohertz}$$

ON-TIMING CAPACITOR CALCULATION

15. Given the necessary tON calculated above, the value of on-timing capacitor C2B can be approximated as follows below:

16. During tOFF, flyback of inductor L1B charges on-timing capacitor C2B to a voltage equal the forward voltage Vf of light-emitting diode D1B, less the base-emitter voltage Vbe of transistor Q1B. Accordingly, C2B charges to approximately 4.2 V – 0.6 V = 3.7 volts.

17. At the commencement of tON, transistor Q2B switches its collector approximately to 0 volts, causing the voltage at the base of transistor to be: -[Vf(D1B) - Vbe(Q1B)], or approximately -3.7 volts.

18. The inital voltage Eo across timing resistor R3B is:
Eo = Vcc + (Vf(D1B) - Vbe(Q1B)) (**Eqn. E-3**) = 1.5 V + (4.2 V - 0.6V) = 5.1 volts

19. In order for the voltage at the base of Q1B to reach Vbe(Q1B), capacitor C2B must first charge by:

$$Ec(t) = Vf(D1B) \text{ volts } (\textbf{Eqn. E-4}) = 4.2 \text{ volts}$$

20. tON terminates when the voltage at the base of transistor Q1B reaches Vbe(Q1B), approximately 0.6 volts.

21. From basic physics, the voltage Ec at time t across the capacitor of a resistor-capacitor timing circuit with an applied voltage E increases as:

$$Ec(t) = E \bullet (1 - e^{-t/rc}) \quad \text{(Eqn. E-5)}$$

22. Solving eqn. E-5 for C yields:

$$C = \frac{t}{R \ln [E / (E-Ec(t))]} = \frac{26.4 \text{ microseconds}}{1{,}800 \text{ ohms} \bullet \ln [5.1V / (5.1V - 4.2V)]} = 8.5 \text{ nanofarads}$$

23. The calculated value of on-timing capacitor C2B is 8.5 nanofarads.

SUMMARY OF RESULTS

24. The solutions above of the equations for tON, tOFF, duty cycle, and frequency of operation of the Invention are unique; these are the only values possible that realize the teachings of the instant invention given the restraints set forth in section 5 above.

25. The foregoing sections derive unique parametric values, which are dictated by the Invention's inventive concepts within the environment recited in section 5. Table E-1 summarizes the results.

Table E-1

	Wener	The Invention	Ratio
tON	1.03μS	26.4μS	2,560 %
tOFF	460nS	15.8μS	3,430 %
switching frequency	671KHz	23.7KHz	2,830 %
inductance L	220μH	220μH	100 %
on-timing capacitor	330pF	8.5nF	2,580%
on-timing resistor	1.8K	1.8K	100 %
off-timing capacitor	1nF	n/a	--
off-timing resistor	560 ohms	n/a	--

DECLARATION

26. I further declare that all statements made herein of my own knowledge are true and that all statements made upon information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application and any patent issuing therefrom.

Signature Date

_____ _____

James Arthur